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LARVAL DEVELOPMENT OF *ILLEX* STEENSTRUP, 1880, IN THE NORTHWESTERN ATLANTIC, WITH COMMENTS ON *ILLEX* LARVAL DISTRIBUTION

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Abstract.—The larval development of *Illex* is described and figured with particular attention to development of the tentacles and the fourth pair of arms. The larvae can be identified by the presence of relatively short fused tentacles which have 8 suckers of uniform size. By the time the tentacles separate they have developed 8 rows of sucker buds in the dactylus. Growth of the tentacles appears to occur at the base as well as the distal tip and the fused area separates rapidly at about 8.50 mm dorsal mantle length. Larval *Illex* collected primarily in subsurface samples from boreal waters along the outer Continental Shelf of the Middle Atlantic Bight in February and March 1977 are considered to be *I. illecebrosus*. *Illex* sp. larvae were also taken in subsurface samples from tropical waters in the mid-shelf region of the Middle Atlantic Bight during August 1977 and in surface samples over the Hatteras Abyssal Plain in February and March 1978.

Although there is some question as to whether post-embryonic cephalopods can be termed larvae (Boletzky, 1974), one family of oegopsid squids, the Ommastrephidae, hatch in a form which is morphologically distinct from the adult form. Larval ommastrephids lack the fourth, or ventral, pair of arms, and at least in some species the third pair, and exhibit fusion of the pair of tentacles into a single appendage with suckers confined to the distal end. The fused tentacles have been referred to variously as a snout (Chun, 1910; Naef, 1923), a rostrum (Hamabe, 1961), or a proboscis-like rod (Okutani and McGowan, 1969). Although Chun (1903) named these larvae with fused tentacles *Rhynchoteuthis*, which was later changed to *Rhynchoteuthion* because of previous assignment of the former name to a fossil form (Pfeffer, 1908), he was aware that they were actually developmental stages of the family Ommastrephidae (Chun, 1910). The term "rhynchoteuthion" is now used for all such ommastrephid larvae.

One ommastrephid species, *Illex illecebrosus*, the short-finned or bait squid, has become increasingly important as a fishery resource (NMFS, 1977). In the western North Atlantic it ranges from Newfoundland and Labrador southward all along the east coast of North America but it is predominantly a cold water species. A sympatric species, *I. oxygonius*, has been captured as far north as the Chesapeake Bight (Roper, Lu, and Mangold, 1969).

This paper describes the larval development of *Illex* based on 47 specimens collected in the Middle Atlantic Bight in February–March 1977. The distribution of these larvae is presented, as well as the distribution of an ecologically distinct form collected in the Middle Atlantic Bight in August 1977 and over the Hatteras Abyssal Plain in February–March 1978.

Methods.—As part of a baseline study of the Middle Atlantic Continental Shelf, zooplankton and other data were collected quarterly along 2 transects extending from near shore to the shelfbreak, one off the eastern shore of Virginia and the other off New Jersey. Both surface and subsurface zooplankton were collected at 12 stations, 9 of which were occupied for 24 hours with surface collections every 3 hours using a neuston frame (Bartlett and Haedrich, 1968) rigged with a standard 1 m 505 μm mesh net. Subsurface oblique tows were made at night with 60 cm opening-closing bongo systems (McGowan and Brown, 1966) rigged with both 202 and 505 μm mesh nets. At the remaining 3 stations, in addition to the night bongo tows, a single night neuston sample was taken. Samples were preserved in 2–4% formaldehyde in sea water buffered with borax.

Specimens from the Hatteras Abyssal Plain were collected during the R/V *Columbus Iselin* deep sea cruise CI7802, conducted by the Virginia Institute of Marine Science during February–March 1978, in the western North Atlantic. A total of 32 stations was occupied, and at least one neuston tow was made at 18 stations. Subsurface collections were made at 4 stations using a modified Tucker trawl rigged with a 1 m 505 μm mesh net. These samples were also preserved in buffered formaldehyde in sea water.

All rhynchoteuthion larvae were examined at between 7 and 40 power under a dark field dissecting microscope equipped with an ocular micrometer. Dorsal mantle length (DML) was measured to the nearest 0.05 mm. Particular attention was directed to tentacular sucker arrangement, structure of the mantle component of the funnel locking cartilage, chromatophore patterns, and the presence of photophores or funnel pit folds. Internal examination was made by cutting the ventral mantle between the siphon and the posterior tip. Several specimens were stained with a solution of 10 mg Alcian Blue in 80 ml of ethanol and 20 ml of glacial acetic acid (Dingerkus and Uhler, 1977) to highlight cartilage structure. This also had the advantage of making developing organs such as buccal lappets and sucker buds easier to see.

Materials.—A total of 51 *Illex* sp. was examined. Of these, 39 were captured in boreal water and 12 in tropical water from calculated catches of 47 and 25, respectively, several specimens having been removed from splits of large samples. All larval and early juvenile *Illex* were taken in plankton tows using either 1 m neuston or 60 cm bongo frames with nets of either 202 or 505 μm mesh. In the gear designations listed below an abbreviation of B202 refers to a 60 cm bongo frame rigged with 202 μm mesh Nitex netting, B505 a 60 cm bongo with 505 μm netting, and N505 a 1 m neuston net of 505 μm netting.

In the following list of specimens examined, I include the VIMS collection number, number of specimens, range of dorsal mantle lengths, cruise designation, station designation, coordinates, station depth, date of collection, time of collection (EST), collecting gear, depth of collection, surface temperature, and surface salinity.

Illex sp.

Z77-002, 1 specimen, 15.15 mm, BLM06W, L6, 37°04.7′N, 74°34.6′W, 274 m, 20:II:77, 1740 hrs, N505, surface, 11.6°C, 35.8‰; Z77-003, 1 specimen, 4.30 mm, BLM06W, L6, 37°05.0′N, 74°33.3′W, 274 m, 20:II:77, 2040 hrs, N505, surface, 11.8°C, 35.8‰; Z77-009, 4 specimens, 4.00–6.30 mm, BLM06W, L6, 37°04.6′N, 74°33.4′W, 301 m, 22:II:77, 0125 hrs, B202, 0–300 m, 12.0°C, 35.8‰; Z77-011, 9 specimens, 3.65–11.00 mm, BLM06W, L6, 37°04.9′N, 74° 31.7′W, 382 m, 22:II:77, 0235 hrs, B505, 0–300 m, 12.0°C, 35.8‰; Z77-042, 4 specimens, 2.40–4.40 mm, BLM06W, J1, 38°46.4′N, 73°00.1′W, 340 m, 26:II:77, 2254 hrs, B505, 0–380 m, 11.2°C, 35.6‰; Z77-044, 1 specimen, 5.60 mm, BLM06W, J1, 38°45.3′N, 73°01.3′W, 360 m, 27:II:77, 0222 hrs, B202, 0–430 m, 11.2°C, 35.6‰; Z77-045, 1 specimen, 3.70 mm, BLM06W, J1, 38° 44.0′N, 73°00.6′W, 360 m, 27:II:77, 0235 hrs, N505, surface, 12.0°C, 35.8‰; Z77-051, 3 specimens, 4.10–13.70 mm, BLM06W, J1, 38°44.0′N, 73°00.0′W, 335 m, 27:II:77, 1755 hrs, N505, surface, 10.4°C, 35.1‰; Z77-052, 3 specimens, 3.50–4.50 mm, BLM06W, J1, 38°45.1′N, 73°01.0′W, 335 m, 27:II:77, 2032 hrs, N505, surface, 10.3°C, 35.1‰; Z77-054, 3 specimens, 5.45–6.30 mm, BLM06W, F2, 38°44.4′N, 73°09.2′W, 107 m, 28:II:77, 0125 hrs, B202, 0–65 m, 7.4°C, 35.5‰; Z77-059, 1 specimen, 3.00 mm, BLM06W, E3, 38°41.9′N, 73°33.0′W, 41 m, 28:II:77, 2310 hrs, B505, 0–20 m, 6.4°C, 35.4‰; Z77-061, 1 specimen, 3.10 mm, BLM06W, E3, 38°41.0′N, 73°32.0′W, 58 m, 28:II:77, 2350 hrs, B202, 0–26 m, 6.4°C, 35.4‰; Z77-062, 1 specimen, 4.80 mm, BLM06W, E3, 38°41.2′N, 73°32.2′W, 49 m, 1:III:77, 0125 hrs, B505, 0–35 m, 6.4°C, 35.4‰; Z77-063, 1 specimen, 3.75 mm, BLM06W, E3, 38°41.2′N, 73°32.2′W, 49 m, 1:III:77, 0125 hrs, B202, 0–35 m, 6.4°C, 35.4‰; Z77-064, 2 specimens, 4.25–5.55 mm, BLM06W, E3, 38°41.3′N, 73°32.4′W, 49 m, 1:III:77, 0200 hrs, B505, 0–38 m, 6.4°C, 35.4‰; Z77-095, 1 specimen, 3.55 mm, BLM06W, A2, 39°21.7′N, 72°32.4′W, 136 m, 3:III:77, 2000 hrs, B202, 0–105 m, 5.4°C, 35.1‰; Z77-096, 1 specimen, 4.50 mm, BLM06W, A2, 39°21.8′N, 72°31.5′W, 136 m, 3:III:77, 2100 hrs, B202, 0–95 m, 5.7°C, 35.0‰; Z77-097, 1 specimen, 4.80 mm, BLM06W, A2, 39°21.8′N, 72°31.5′W, 136 m, 3:III:77, 2100 hrs, B505, 0–95 m, 5.7°C, 35.0‰; Z77-144, 1 specimen, 21.10 mm, BLM07W, L4, 37°08.2′N, 74°37.0′W, 86 m, 20:V:77, 0440 hrs, N505, surface, 17.6°C, 35.8‰; Z77-250, 1 specimen, 2.40 mm, BLM08W, L2, 37°20.1′N, 74°58.7′W, 42 m, 20:VIII:77, 2050 hrs, B202, 0–35 m, 25.0°C, 31.7‰; Z77-297, 1 specimen, undetermined, BLM08W, A2, 39°21.5′N, 72°30.9′W, 128 m, 25:VIII:77, 2055 hrs, B202, 0–90 m, 23.3°C, 33.5‰; Z77-300, 1 specimen, 2.05 mm, BLM08W, A2, 39°21.3′N, 72°30.9′W, 128 m, 25:VIII:77, 2200 hrs, B505, 0–90 m, 23.3°C, 33.5‰; Z77-313, 1 specimen, 2.10 mm, BLM08W, B5, 39° 27.1′N, 73°02.1′W, 64 m, 26:VIII:77, 2020 hrs, B505, 0–37 m, 22.1°C, 32.1‰; Z77-333, 2 specimens, 2.55–2.65 mm, BLM08W, D1, 39°04.5′N, 73°53.4′W, 39 m, 28:VIII:77, 1855 hrs, B505, 0–13 m, 21.8°C, 32.6‰; Z77-337, 3 specimens, 2.75–3.70 mm, BLM08W, N3, 38°51.1′N, 73°44.9′W, 43 m, 28:VIII:77, 2120 hrs, B505, 0–38 m, 24.1°C, 32.6‰; Z78-008, 2 specimens, undetermined—3.20 mm, CI7802, BRI8, 38°08.1′N, 68°48.2′W, 3980 m, 20:II:78, 2300 hrs, N505, surface, 19.2°C, 36.4‰; Z78-024, 1 specimen, 8.50 mm, CI7802, 23, 36°48.4′N, 71°23.7′W, 4134 m, 3:III:78, 0906 hrs, N505, surface, 19.0°C, unknown.

Identification.—Little progress has been made in identification of rhynchoteuthion larvae to species. Naef (1923) discussed the general post-embryonic development of the family and described late larvae, which had the fourth pair of arms developed and tentacles mostly separated, of *Todarodes sagittatus* and *Ommastrephes bartrami.* He also described a juvenile *Illex coindetii* in which the tentacles had just separated. Allan (1945) assigned all of the rhynchoteuthion larvae collected off the eastern Australian coast to *Nototodarus gouldi.* Hamabe (1961, 1962) described the embryonic and post-embryonic development of *Todarodes pacificus* based on laboratory hatched and planktonic specimens. Clarke (1966) mentioned and figured two rhynchoteuthion larvae referable to either *O. caroli* or *O. pteropus* based on funnel connective structure. Development in *Symplectoteuthis oualaniensis* was figured by Silas (1968). Yamamoto and Okutani (1975) discussed three rhynchoteuthion types, one of which they assigned to *S. oualaniensis.*

Tentacles: Knowledge of the tentacular structure and development is of utmost importance in the identification of rhynchoteuthion larvae. One of the primary characters used to separate the genus *Illex* from other ommastrephid genera is the presence of 8 rows of suckers in the dactylus of the tentacle. In the larvae this pattern becomes apparent at about 8.5 mm DML.

A pattern of the 8 original suckers like that found in the larvae of some other ommastrephid species is present in *Illex.* Okutani and McGowan (1969) figured a similar pattern from a "small" Pacific specimen. Differences exist, though, between their figure and the pattern in *Illex.* They showed the tip to be elliptical in shape and size differences to exist in the suckers with the lateral suckers being largest and the smallest suckers in the middle. In *Illex* the tip is diamond shaped and the suckers are all the same size. They also stated that the smallest sizes have only 6 tentacular suckers. Chun (1910) described all of the rhynchoteuthion larvae that he examined as having 8 suckers at the "apex" of the tentacles, but his figures showed that the tentacular tip was not expanded and the suckers were in a circular arrangement. The youngest stages of rhynchoteuthion described by Naef (1923) bore only 4 tentacular suckers, but his advanced larvae of *T. sagittatus* and *O. bartrami* exhibited tentacular development which is quite similar to that described in this paper, including the 8 developed suckers and the 4 rows of sucker buds. They, of course, never developed 8 rows in the dactylus.

Relative tentacular length may be of taxonomic importance. Although the tentacles of adult squid are notoriously contractile, this is not necessarily true of larvae and early juveniles. The tentacle length of juvenile *Loligo pealei* (1.4–15.0 mm DML) examined by the author is closely correlated with dorsal mantle length. Although insufficient material is available to perform a morphometric study of *Illex* larvae, variability other than growth in the tentacle length of the specimens examined was not apparent. The tentacles were never functionally longer than the arms. But several authors (Chun, 1910; Naef, 1923; Silas, 1968; Okutani and McGowan, 1969; Morales and Guerra, 1977) have figured rhynchoteuthion specimens in which the fused tentacles were much longer than the arms.

Mantle cartilages: Other than the genus *Illex*, ommastrephid squids which are likely to be found in the study area belong to the genera *Ommastrephes* and *Ornithoteuthis*. One character that separates *Illex* from *Ommastrephes* is the structure of the mantle component of the funnel locking cartilage. In *Ommastrephes* the anterior ridge is bifurcate whereas in *Illex* it is simple (Wormuth, 1976). All larvae examined in this study had the form found in *Illex*.

Foveola: A character which distinguishes the subfamily Illicinae from the rest of family Ommastrephidae is the presence of a funnel pit which is open without either longitudinal folds or secondary pockets (Muus, 1963). Naef (1923) stated that these folds are clearly visible in older rhynchoteuthion stages, but they were not present in any of the squid examined for this study.

Chromatophores: Naef (1923) and Muus (1963) indicated that chromatophore patterns are very useful in the identification of juvenile and larval cephalopods. However, the net captured specimens examined here had been damaged during capture and preservation and the only pattern which consistently remained was that of the 3 ventral chromatophores on the head. Similar patterns have been figured for *T. sagittatus*, *O. bartrami* (Naef, 1923), *T. pacificus* (Hamabe, 1962), and *S. oualaniensis* (Silas, 1968) but not in the same arrangement.

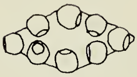
Photophores: Intestinal photophores are present in *O. pteropus* and are highly visible in the juveniles (Wormuth, 1976) but were not found in *Illex*.

Development and discussion of development.—The smallest specimens taken, DML ~ 2.40–5.00 mm, were similar in form to the individual in Fig. 1 (DML = 3.60 mm). The second and third pair of arms were about equal in length, although in the smallest larvae the third pair was somewhat shorter than the second. The fourth pair of arms was recognizable only as small protuberances with no suckers. The tentacles were fused along their entire length in the smallest specimens, although at about the size illustrated in Fig. 1 a small gap could be seen at the base. The distal tip of this tentacular organ was expanded and concave. Eight suckers were confined to this concavity and arranged from side to side in the order 1–2–2–2–1.

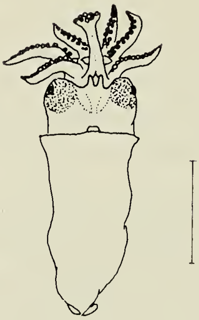
Figure 2, based on a specimen of 7.00 mm DML, was representative of larvae ranging in size from 5.00–8.00 mm. The third pair of arms had lengthened, strengthened, and developed a swimming margin. The ventral protuberances seen in smaller larvae had developed into the fourth pair of arms complete with biserial suckers which were fully developed along the proximal one-third, but still developing from buds along the distal two-thirds. Although all of the cephalic appendages had lengthened, their length was shorter relative to dorsal mantle length than those of the smaller squids. The fused tentacles were considerably shorter than any except the fourth pair of arms. While the length of the fused area, about 1.00–1.30 mm, remained the same as in smaller larvae, growth appeared to have occurred in two places. The separated area at the base of the tentacles had lengthened as had the tips of both tentacles. On both sides of the original expanded tip, which still had the same pattern of 8 fully developed suckers, were 4 rows of tiny sucker buds or *Anlagen* (Naef, 1923). Two chromatophores were visible on the ventral surface of the head, one below each eye.

The squid shown in Fig. 3 (DML = 8.50 mm) represents larvae in transition just prior to separation of the tentacles and assumption of the juvenile form. The third pair of arms was very robust. The fourth arms had further lengthened and developed more suckers. The most interesting developments, however, were in the tentacular structure. The separated sections at the bases had lengthened considerably. The tips had also lengthened and had folded together anteriorly. Many more sucker buds were present and the smallest ones at the distal extremities of the tentacles appeared to be arranged in 8 rows. Three chromatophores were visible on the ventral surface of the head, one below each eye and one on the midline just anterior to the funnel.

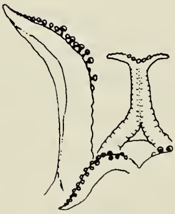
Figure 4 was drawn from a juvenile *Illex* with a dorsal mantle length of 11.00 mm. The fourth pair of arms was still the shortest of the cephalic appendages. The tentacles had separated and were about the same length as the third pair of arms. The original 8 suckers had been divided between the two tentacles while several more suckers had developed from the earliest sucker buds mentioned in the description of Fig. 2. The smallest, outermost sucker buds were arranged in 8 rows. The tentacles were not as robust as



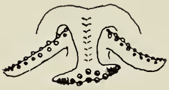
1A



1B



2A



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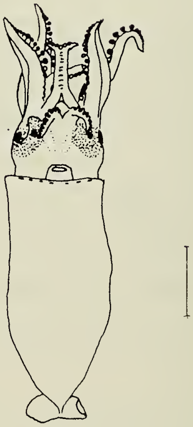

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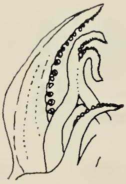

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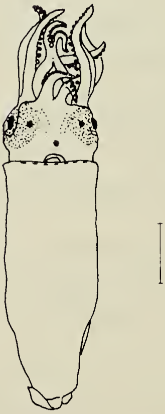

3B

any of the arms, and in most of the other specimens of early juveniles in which the tentacles had become separated they had been damaged, probably during capture, while the arms remained intact. Three chromatophores were present on the ventral head in the same locations as those described in Fig. 3.

While the specimens drawn in Figs. 1–4 all came from the same collection, the one in Fig. 5 (DML = 21.10 mm) was taken from the same area, but three months later. Other than morphometrics and the presence of the mantle skin with its chromatophores, it is little different from the specimen illustrated in Fig. 4. The dactylus of the tentacle still has 8 tightly packed rows of undeveloped sucker buds. The 3 chromatophores on the ventral surface of the head are still recognizable. Basically, this specimen differs from adult *Illex* only in the absence of developed sexual organs.

All specimens examined lacked funnel pit folds and photophores. In all cases the anterior section of the mantle component of the funnel locking cartilage was simple rather than bifurcate. Unfortunately the skin had been abraded on almost every specimen, thus development of mantle chromatophore patterns could not be followed.

Third pair of arms: Various researchers have described rhynchoteuthion larvae smaller than any specimen found in this study and in which the third arms had not yet developed; the third arms were present and functional in the smallest specimens described here. Hamabe (1961) stated that in *Todarodes pacificus* hatched in culturing experiments the third arms, which were undeveloped at hatching, had become longer and stronger than the first and second arms within a day or two after hatching. But since the larvae were not capable of swimming it seems likely that they had hatched prematurely, as frequently happens in cultured cephalopods. A photograph, published by Boletzky (1974), of laboratory hatched *Illex coindetii* showed a post-hatching stage in which the third arms were missing but was also based on cultured material. Occurrences in the plankton of unidentified rhynchoteuthion larvae in which the third pair of arms had not yet developed include Chun (1910) and Okutani and McGowan (1969). Naef (1923) stated that this is typical of the postembryonic development in the family Ommastrephidae.

Fourth pair of arms: It is generally agreed that the fourth pair of arms are the last cephalic appendages to develop in rhynchoteuthion larvae. This can also be considered typical of ommastrephid development (Naef, 1923).

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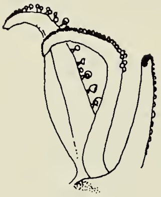
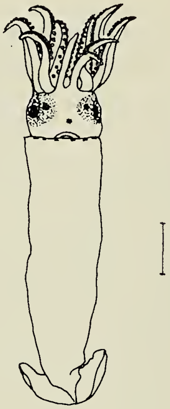
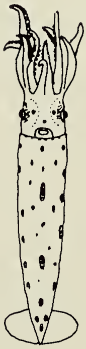
Figs. 1–3. *Illex* sp. larvae from boreal water. 1: DML = 3.60 mm; 1A, Sucker arrangement at tip of fused tentacles; 1B, Ventral view of entire animal; 2: DML = 7.00 mm; 2A, Tentacles, third arm, and fourth arm; 2B, Tentacles showing sucker arrangement at distal tip; 2C, Ventral view of entire animal; 3: DML = 8.50 mm; 3A, Tentacles, third arm, and fourth arm; 3B, Ventral view of entire animal. Scale lines = 2.00 mm.



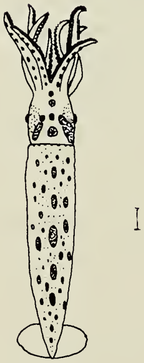
4A



4B



5A



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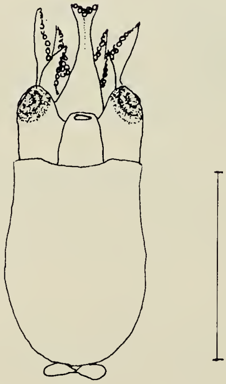

6

Tentacles: The late development of the 8 rows of sucker buds characteristic of the dactylus, together with the lengthening of the distal tips of the tentacles beyond the constant 8 fully developed suckers, supports Naef's (1923) statement that larval tentacles grow at the distal tips and that therefore the dactylus forms last. But there appears to be another area of tentacular growth, at least in *Illex*. The separated area at the bases of the tentacles lengthened consistently with increase in dorsal mantle length while the length of the fused area proximal to the 8 suckers remained constant, indicating growth occurring somewhere in the basal area. Separation of the fused area is not a gradual "unzipping" with growth of the animal. It occurs rapidly at about 8–9 mm DML and results in a weakened tentacle. Similar tentacular weakness after separation has been described for *O. bartrami* and *T. pacificus* by Okutani (1968).

Distribution and discussion of distribution.—During the period 20 February–6 March 1977, 47 rhynchoteuthion larvae and early juvenile *Illex*, DML 2.40–15.15 mm, were collected. With the exception of one mid-shelf station, which actually clusters faunistically with the outer-shelf stations (Grant, 1977), all were from outer shelf stations (Fig. 7).

Although 75 out of 117 samples taken on this cruise were surface neuston tows, 76.5% of the collections in which *Illex* occurred were subsurface bongo tows. These accounted for 83% of the *Illex* specimens collected. All neuston samples which included *Illex* were collected at night.

Because the bongo tows were oblique, the only reliable temperature and salinity data for the collections that we have are for the neuston collections. Since only 4 neuston tows caught *Illex* this is too small a sample to make inferences from. The temperature range of these neuston tows was 10.4–11.8°C while salinity ranged from 35.1–35.8‰. However, 76.9% of all winter collections that included *Illex* also included *Limacina retroversa*, a thecosome pteropod species which is a reliable indicator of boreal water (Bigelow, 1922; Chen and Be, 1964; Chen and Hillman, 1970).

A second group of 32 rhynchoteuthion larvae was collected during 20–28 August 1977. Of these, 22 were *Illex*, DML 2.10–3.70 mm, which were consistently smaller than the specimens collected the previous winter. The smaller size made direct morphological comparisons with the winter specimens impossible since differences (Fig. 6) could be the result of being at a different growth stage. The stations at which these *Illex* larvae were

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Figs. 4–5. *Illex* sp. juveniles from boreal water. 4: DML= 11.00 mm; 4A, Tentacle, third arm, and fourth arm; 4B, Ventral view of entire animal; 5: DML = 21.10 mm; 5A, Ventral view; 5B, Dorsal view. Fig. 6. *Illex* sp. larva from tropical water, DML = 2.40 mm. Scale lines = 2.00 mm.

Table 1. Summary of *Illex* collection data.

Species	Cruise	Developmental stage	N	DML range (mm)	Station depth range (m)	Surface temperature range (°C)	Surface salinity range (‰)	Gear	Water mass indicator species
Ilex illecebrosus	BLM06W	larv., juv.	47	2.40–13.70	41–360	5.4–12.0	35.0–35.8	B505 B202 N505	*Limacina retroversa*
Illex illecebrosus	BLM07W	juv.	1	21.10	86	17.6	35.8	N505	*L. trochiformis, Creseis virgula, Cavolina longirostris*
Illex sp.	BLM08W	larv.,	22	2.10–3.70	39–128	21.8–25.0	31.7–33.5	B505	*L. trochiformis, C. virgula, C. longirostris*
Illex sp.	CI7802	larv., juv.	3	3.20–8.50	3,980–4,134	19.0–19.2	36.4	N505	*L. trochiformis, C. acicula, C. longirostris*

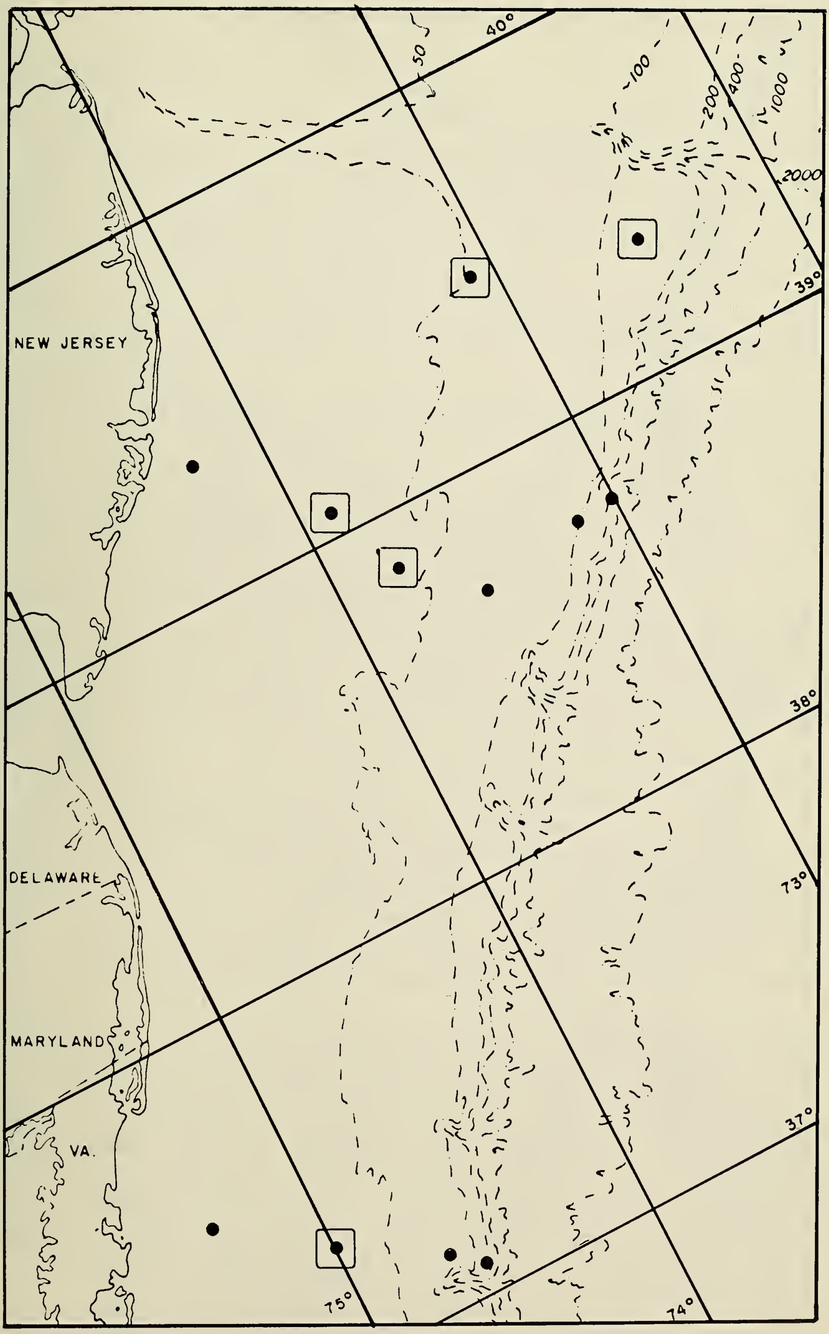

Fig. 7. Distribution of larval and juvenile *Illex* sp. February–March 1977. Stations sampled (●); stations at which *Illex* sp. were collected (□).

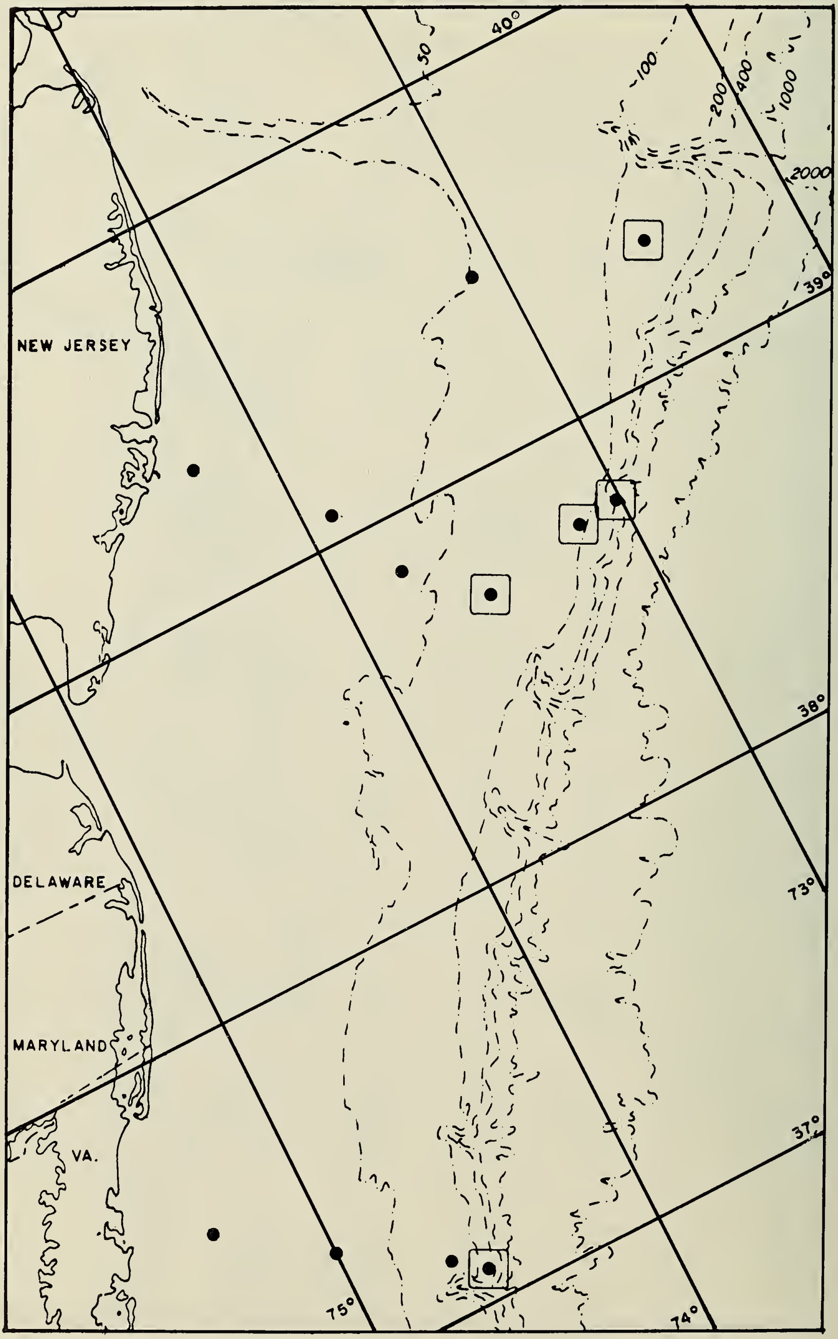

Fig. 8. Distribution of larval *Illex* sp. August 1977. Stations sampled (●); stations at which *Illex* sp. were collected (□).

collected (Fig. 8) were generally much shallower than those at which *I. illecebrosus* were found during the winter, and the surface temperatures were much higher, whereas surface salinities were lower. Thecosome water mass indicator species which were present at all of these stations include *Limacina trochiformis*, *Creseis virgula* and *Cavolinia longirostris*, which are indicators of tropical water (Chen and Hillman, 1970). Although remnants of boreal fauna, including *Sagitta elegans* and *Evadne nordmanni*, remained in the area, these *Illex* larvae were not more than a few days old and could not have been part of this remnant community.

Additionally, two *Illex* larvae and one juvenile were collected in neuston tows, one night and one day, in Gulf Stream water far offshore in February and March 1978.

Although Clarke (1966) postulated by extension of a graph from Squires (1957) that *I. illecebrosus* spawn in the summer, Squires (1967) fitted more extensive data into a von Bertalanffy growth equation and then extrapolated to a hatching time of January or February. If the growth rate of larval *Illex* is assumed to be similar to that of *T. pacificus* (Hamabe, 1962), the smallest sizes described here could not have been more than about two days old and therefore could not have drifted far from the hatching site. The larvae taken at our northernmost stations were beyond the reported northern range limits of *I. oxygonius* and boreal specimens taken there are probably *I. illecebrosus.* Although those specimens collected at the other stations were within the range of *I. oxygonius*, sufficient continuity exists between the winter samples to assume that all specimens were *I. illecebrosus.* The February–March capture of these specimens supports Squires' (1967) calculated winter hatching time for *Illex illecebrosus.*

Catching *Illex* larvae in tropical water masses certainly brings up the possibility that they are the southern species, *I. oxygonius*, but several of these were also taken north of the published range limits of *I. oxygonius.* So many ecological differences exist between these and the boreal, winter caught specimens that I am unwilling to assign them to a species at this time.

Conclusions.—Based on the funnel pit and mantle cartilage structure and the arrangement of tentacular suckers in the larger specimens, the rhynchoteuthion larvae described in this paper belong to the genus *Illex* and based on distribution the boreal specimens are *I. illecebrosus.* It is possible that younger stages exist in which the third pair of arms is not developed. Although these larvae were found in the Middle Atlantic Bight, their distribution quite likely extends farther to the north and to the south. Tentacular growth appears to occur at both the tip and the base, and separation of the fused area is comparatively rapid, resulting in weakened tentacles in the early juvenile squid.

Further sampling is necessary to resolve the identity of specimens taken in tropical water, to identify spawning and hatching areas, and to obtain better specimens for a more complete larval description including chromatophore patterns, morphometrics, and possible smaller sizes.

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Literature Cited

Allan, J. 1945. Planktonic cephalopod larvae from the eastern Australian coast. Rec. Austr. Mus. 21:317–350.

Bartlett, M. R., and R. L. Haedrich. 1968. Neuston nets and South Atlantic larval blue marlin (*Makaira nigricans*). Copeia 1968:469–474.

Bigelow, H. B. 1922. Exploration of the coastal water off the northeastern United States in 1916 by the U.S. Fisheries schooner *Grampus*. Bull. Mus. Comp. Zool. 65:87–188.

Boletzky, S. V. 1974. The "larvae" of Cephalopoda: a review. Thalassia Jugosl. 10:45–76.

Chen, C., and A. W. H. Be. 1964. Seasonal distributions of euthecosomatous pteropods in the surface waters of five stations in the western North Atlantic. Bull. Mar. Sci. Gulf. Carib. 14:185–220.

Chen, C., and N. S. Hillman. 1970. Shell-bearing pteropods as indicators of water masses off Cape Hatteras, North Carolina. Bull. Mar. Sci. 20:350–367.

Chun, C. 1903. *Rhynchoteuthis*. Eine merkwürdige Jugendform von Cephalopoden. Zool. Anz. 26:716–717.

———. 1910. The Cephalopoda. Valdivia Repts. 18:1–436.

Clarke, M. R. 1966. A review of the systematics and ecology of oceanic squids. Adv. Mar. Biol. 4:91–300.

Dingerkus, G., and L. D. Uhler. 1977. Differential staining of bone and cartilage in cleared and stained fish using Alcian Blue to stain cartilage and enzymes for clearing fish. Paper presented at the fifty-seventh Annual Meeting of the American Society of Ichthyologists and Herpetologists, Gainesville, Florida.

Grant, G. C. 1977. Middle Atlantic Bight zooplankton: seasonal bongo and neuston collections along a transect off southern New Jersey. Va. Inst. Mar. Sci. SRAMSOE 173:1–138.

Hamabe, M. 1961. Experimental studies on breeding habit and development of the squid *Ommastrephes sloani pacificus* Steenstrup. IV. Larval structure particularly at rhynchoteuthis stage. Zool. Mag. Tokyo 70:421–424.

———. 1962. Studies on breeding habit and larval development of the squid *Ommastrephes sloani pacificus* Steenstrup. V. Formation of the fourth arm and the tentacle in the rhynchoteuthis larvae. Zool. Mag. Tokyo 71:65–70.

McGowan, J. A., and D. M. Brown. 1966. A new opening-closing paired zooplankton net. Univ. Calif., Scripps Inst. Oceanogr. Ref. 66-23.

Morales, E., and A. Guerra. 1977. Teuthoidea: Oegopsida del NW de Africa. Inv. Pesq. 41:295–322.

Muus, B. J. 1963. Cephalopoda Sub-Order: Teuthoidea Families: Ommastrephidae, Chiroteuthidae, Cranchiidae. Fich. Ident. Zooplankton 96.

Naef, A. 1923. Cephalopoda. Fauna Flora Bay of Naples 35:1–917.

National Marine Fisheries Service. 1977. Fisheries of the United States, 1976. NMFS CFS 7200: 96 pp.

Okutani, T. 1968. Studies on early life history of decapoden mollusca. III. Systematics and distribution of larvae of decapod cephalopods collected from the sea surface on the Pacific coast of Japan. Bull. Tokai Reg. Fish. Res. Lab. 55:9–57.

Okutani, T., and J. A. McGowan. 1969. Systematics, distribution and abundance of the epiplanktonic squid (Cephalopoda, Decapoda) larvae of the California Current April 1954–March 1957. Scripps Inst. Oceanogr. Bull. 14:1–90.

Pfeffer, G. 1908. Die Cephalopoden. Nord. Plank. Lief 9(4):9–116.

Roper, C. F. E., C. C. Lu, and K. Mangold. 1969. A new species of *Illex* from the western Atlantic and distributional aspects of other *Illex* species. Proc. Biol. Soc. Wash. 82:295–322.

Silas, E. G. 1968. Cephalopoda of the West Coast of India collected during the cruises of the research vessel *Varuna*, with a catalogue of the species known from the Indian Ocean. Symp. Mollusca Proc. 1:275–359.

Squires, H. J. 1957. Squid, *Illex illecebrosus* (Le Sueur), in the Newfoundland fishing area. Jour. Fish. Res. Bd. Canada 14:693–728.

———. 1967. Growth and hypothetical age of the Newfoundland bait squid *Illex illecebrosus illecebrosus*. Jour. Fish. Res. Bd. Canada 24:1209–1217.

Steenstrup, J. 1880. The interrelationships of the *Ommastrephes*-like cephalopods. An orientation. Overs. danske Vidensk. Selsk. Forh. 1880–1881: 73–110. English translation: A. Volse, J. Knudsen and W. J. Rees. 1962. The cephalopod papers of Japetus Steenstrup. Danish Science Press. Copenhagen. 330 pp.

Wormuth, J. H. 1976. The biogeography and numerical taxonomy of the oegopsid squid family Ommastrephidae in the Pacific Ocean. Scripps Inst. Oceanogr. Bull. 23:1–90.

Yamamoto, K., and T. Okutani. 1975. Studies on early life history of decapoden Mollusca—V. Systematics and distribution of epipelagic larvae of decapod cephalopods in the southwestern waters of Japan during the summer in 1970. Bull. Tokai Reg. Fish. Res. Lab. 83:45–96.

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